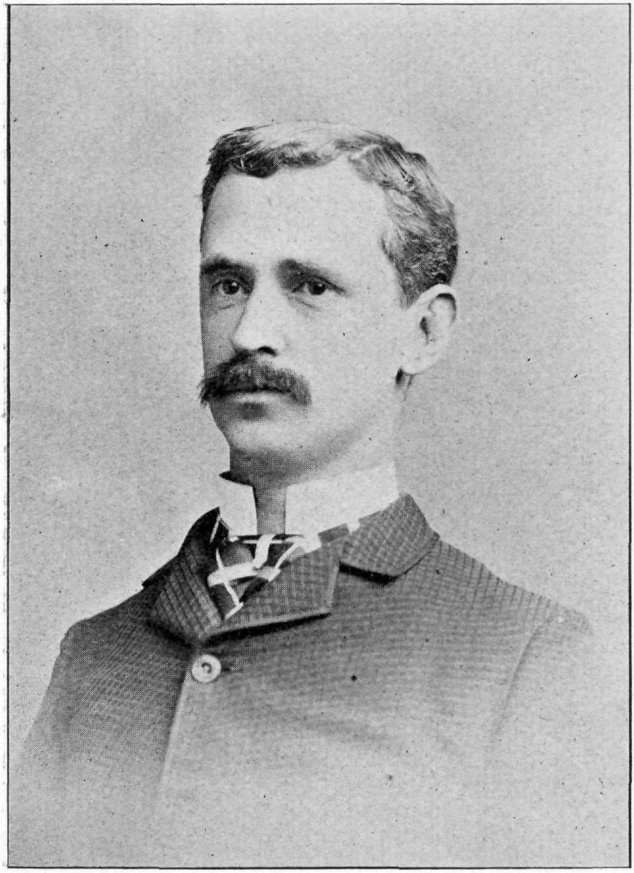

T. E. HUGHES.

WIRE ROPE HAULAGE, ITS USE AND ABUSE.

BY T. E. HUGHES, M. E.

An interchange of ideas on a practical subject of this kind, is bound to result in the common good, and if this paper does not prove an exception to the rule, it will have accomplished the purpose for which it was written.

For underground haulage, there are to-day (generally speaking) three systems in operation in the bituninous coal regions of this country. First, the tail rope system; second, the endless rope, and third, the electric system. Each system has its good points as well as its weak ones, and no engineer or coal operator should let any influence have a bearing upon which method he will adopt other than those produced by the conditions as he finds them at his particular plant.

A general rule to be observed by all, as to the manner of operation, would be one of the worst things to meet with in coal mining. Let me right her quote literally from an article read before the mining engineers of western Pennsylvania, as follows: "It is very essential in deciding which system of mechanical haulage is best adapted to any particular mine, to carefully consider all the conditions to be contended with."

This vital point that is here reiterated (and confirms my remark at the outstart), covers the true secret of a successful haulage system; be its manner of operation what it may. Hence, you will see that any remarks of the author of this paper will have to be considered in a general way, produced by observation of various plants working under very dissimilar conditions, and the suggestions being of a general nature and not applicable to any particular plant until first the conditions of said plant have been carefully studied out.

Genreally speaking, a tail rope system produces more satisfactory results than the endless rope system. First, we can use a tail rope system in single gangways by carrying the tail rope between the tracks, along side the track, or overhead. An endless system (generally speaking), calls for a double gangway, to produce economic results, i. e. the carrying in of empty cars at the same time the loaded ones are being taken out. This is the first reason why the writer would advocate (where the plant admits of so doing) the use of a tail rope system.

The next reason (and it cannot be considered too carefully) is the objectionable feature of the endless rope, i. e. friction. Friction, reduced down to mechanical results, means nothing more or less than wear and tear at points of contact; and if said friction or wear and tear must produce the moving or grasping the load we propose carrying, it certainly means wear and tear of something at some point.

There are several methods of fastening to, or attaching, the loaded train of cars to the endless system; one being two pullies mounted on a small truck, each nearly touching each other at the face of said pullies or sheaves when out of service. The shafts carrying these two pullies being connected together by a right and left hand screw. When said screw is revolved it widens the distance between the pullies, and the endless rope being passed around said pullies, becomes taut, friction accrues, and eventually by friction the rope takes a permanent grip on the pullies, and the train is moved.

Another system, and one more commonly used, is to mount on a small truck a device working on the principle of a vise operated by a screw. I have a blue print here, which will more readily convey to you the idea of the operation of this latter device. This, again, as you see, by the closing of the vice, makes contact with the rope, which, when the friction has been overcome, makes the attachment a permanent one, and the load moves.

I cannot too strongly give the advise that certainly should be heeded in connection with friction, that the apostle Paul did when the young man wanted to ge married—Don't. That covers the whole situation. (I don't know whether this was also the reason or not, Paul had for discounting marriage.)

In operating a wire rope, be it for haulage or other purposes, avoid friction as you would poison. If for no other reason, I would, at all times, advocate putting in a tail rope system for the foregoing reason, even if no other reasons or conditions warrant so doing. A tail rope system, properly put in, with a boiler capacity and power of engines being twenty-five per cent. in excess of any possible requirements, will, in nine cases out of ten, produce the greatest result for the capital invested.

It may have occurred to some of you by this time that I have not referred to the fact that a tail rope system calls for about fifty per cent. more rope than an endless system. True. But actual experience by the rope makers, I think, will demonstrate the following to be a fact: Conditions being equal, two plants side by side, going into a heading ten thousand feet from the power-house, with a tail rope system calling for thirty thousand feet of rope, and another with an endless system like distance and under like conditions (if such a plant ever existed), would result in the tail rope lasting twice as long as the endless rope, thus producing a saving of thirty-three and one-third per cent. on rope bills, where fifty per cent. more rope is in operation, i. e. this fact being produced by the necessity of replacing the endless rope twice as often as the tail rope.

Let me now refer to one or two tail rope systems working under favorable conditions that have produced very satisfactory results, and in a general way, could and should be duplicated anywhere else in the United States, where the coal to be handled would warrant the investment.

First, there is a plant within twenty-five miles of Pittsburg, operating the tail rope system, the length of haul being ten thousand five hundred feet. This, as you see, calls for ten thousand five hundred feet of main rope and twenty-ine thousand feet of tail rope. Their engines are fourteen by twenty-four; drums six feet in diameter; they work under eighty pounds steam pressure; they haul a maximum of ninety cars per trip, loaded as follows: coal four thousand pounds, tare one thousand three hundred pounds, gross five thousand three hundred pounds. There is but little gradient, and that is a maximum of one and one-half per cent. against these empty cars, i. e. in favor of the loaded cars. They make sixteen trips, and it takes forty minutes to make a trip. The engines are geared four to one. They use for the track a thirty pound steel rail well ballasted. Rollers twenty feet apart. The road bed is on a coal bottom, under which is a hard fire clay, and under this fire clay a limestone. This, as you will see, gives what might be termed "an almost ideal condition for a road bed in a coal mine." The mine is well drained to the opening or openings.

Again, I have in my mind's eye, a plant within two hundred miles of Pittsburg. The engines are twenty by thirty; they are geared three to one; they develope four hundred and fifty horse power while hauling a trip of forty cars up a grade of one in twenty; the gross tonnage of load being two hundred and thirty-four tons eight hundred and eighty pounds, divided as follows: coal one hundred and sixty tons, cars sixty tons, weight of rope fourteen tons eight hundred and eighty pounds. The haulage is nine thousand feet from the heading to power-house. They are a one and one-eighth hauling rope, and a three-fourths tail rope. One of the main ropes on this latter plant is still in service, and its mate was taken off this last summer. I forgot to state that this is a double tail rope system.

The main rope and tail rope taken off last summer, hauled one million two hundred thousand tons of coal; consequently, you will see that by a short process of figuring, what the cost of the rope for both hauling the coal represents.

The plant first referred to does not have any conditions of grade scarcely to speak of; in other words, the maximum grade is one and one-half per cent. in favor of the load. They have hauled out over one and one-fourth million tons of coal with thirty thousand feet of three-fourths crucible steel haulage rope, costing for rope, as you will see, two and four-tenths cent per one thousand tons for haulage.

Having now referred to a couple of plants hauling coal under favorable commercial results, I now want to switch back again to general conditions to be observed for operating rope haulages, be they endless, or tail rope; and perhaps one of the most vital and beneficial changes that our engineers have made, is, where we have to make a turn in our gangway at a right angle (or nearly so), they, wherever it is possible, now introduce the reversed curve to overcome the strain resultant from using a guide wheel or carrier.

By using the reverse curve, you can see at a glance, we get a much greater radius and naturally much less bind or set in the rope, than under the old conditions. Observing the fact that the mine engineer will reverse the conditions of the steam railway engineer in the following way: Your inside rail must be elevated above the level of your outside rail, owing to the fact that the pull of the rope will have a tendecy to increase friction if the rails are on the level, while on the contrary it is a question of momentum to be overcome when a railroad engineer of a steam road elevates the outside track instead of the inside, as the mining engineers do.

It will not do to leave the discussion without noticing another important factor in a well equipped plant—that is, the kind and construction of the rope that you use. The kind most commonly used for haulages, is composed of six strands of seven wires each, laid around a hemp center. The wires (generally speaking) being made of steel.

A rope that has received more attention than merit, is what is known as the "Lang Lay" rope. This rope is composed of the same number of wires and strands as the commonly used haulage rope, but differs in this respect,—the strands when being twisted together, are twisted in the same direction as the wires have been in each particular strand. This produces a much more flexible rope than the rope made in the way known as Standard lay. The strands of the Standard laid rope being laid up in the opposite direction to the lay of the wires in the strand.

A flexible rope is a desirable one; if we do not sacrifice some element of vital force equal to or greater than what we gain in flexibility.

There are exceptional cases (which the discussion of this paper may bring out) wherein the Lang Lay rope is the most advisable, but, generally speaking, the Lang Lay rope does not give as good service as the Standard lay.

By examining a section of a Lang lay rope, you will see that the wires run over the pullies at an angle of about forty-five degrees. If each and every pulley is in an ideal condition, i. e. running true, well lubricated, and in first class condition, the construction of the rope will not make a material difference on the life of the same, but are these conditions ever lived up to? I would say "no"; consequently, at just exactly the ratio of the condition of the passing from the ideal to the actual, just at the same ratio does friction "come in" on the wear of the wires on the Lang Lay rope over and above what would be the case with the Standard lay.

To further illustrate this, you will notice that when a mechanic is using a file in filing a piece of metal, he takes the position of the file at exactly the same angle at which these wires are laid, to produce the best results, i. e. cut away the metal to the greatest amount with each stroke of the file. If the mechanic will do it with that object in view, does not the same result follow with the Lang Lay rope, when passing over the pullies full of grit and dirt? Such being the case, rope manufacturers (generally speaking) recognizing the fact, have insisted on the use of the Standard lay rope to produce the best results for the operator.

You will notice in the Standard lay rope, that the wires lay parallel with the motion of the rope, and for this reason when passing over pullies, produces the smallest amount of surface of each wire for friction that is possible, and by so doing, has a tendency to slide over the pullies rather than scrape them.

Again, using the file for an illustration, if you put the file in the mechanic's hand, and tell him to push it over the metal he is filing, with the teeth of his file parallel with the motion of the stroke, he will at once tell you that his file will slide over the material instead of cutting it. This illustration will best serve my purpose, in my effort to indicate why the Lang Lay rope will not give as good service (generally speaking) as the Standard lay.

There are (as I have intimated) exceptional cases where the Lang Lay rope will work, but only exceptional, they being perhaps controlled by the following conditions. "A high speed motion, very small drums, and numerous angles in the operation of the plant."

Under these conditions, perhaps, it might be advisable to use the Lang Lay, on account of its extra flexibility over and above the ordinary haulage rope made of seven wires to the strand; and even in this condition, it is a question which only a rope manufacturer should decide, as to whether a rope made of nineteen wires to the strand (Standard lay) would not give better service than a rope made Lang Lay, seven wires to the strand.

This illustration once more forces upon us—and like Banquo's ghost—"will not down", the fact that friction is an expensive luxury, and only those who need not care what the expense of the luxury so they have it, should ignore its cost.

Before leaving the subject of haulage, we might be considered behind the time if we made no reference to the latest development, i. e. "Electric haulage."

Electric haulage (as being introduced to-day) means haulage by traction, and (getting back to our old hobby again) traction means friction.

The problem—a simple one—is, we must move a given load (the power needed, it is presumed we have at our command) by a sufficient heavy motor to give us the required traction, or in other words, sufficient to reduce the friction between the motor wheels and the rail to nil. This (after careful investigation) I am firmly convinced has, as yet, not been successfully accomplished (looking at the question of commercial economy and success).

Of course, I realize this remark will bring down on my unprotected head, an avalanche of criticism from our electrical engineers, yet I will frankly say right here, that if I am mistaken, I am as anxious as they are to see the error of my ways, and only too gladly will make due apologies, and concessions for such discrepancies as they may point out to me, but, as I now see it, there is not in operation, to my knowledge to-day, an electrical haulage system giving the desired mechanical results, that I would not be willing to guarantee to exceed said mechanical results on less than seventy-five per cent. of the capital invested in the electric installation, by submitting wire rope; hence, if this is so—electricity, is as yet, economically speaking, a failure. In fact, let me close these remarks by suggesting that some of the rules that are given us for success when seeking happiness, will apply fully as forcibly when applied to seeking coal—"avoid friction."

Take the best of care of the health of your plant. See that all things work in harmony. See that "the joints" are well lubricated.

See that each part of "the plant" performs its particular duty. See that it gets the daily care that it should have to enable it to do to-morrow's work as ably as it did to-day's, and rest assured it will live to a ripe old age, and make all happy who come in contact with it. (Applause.)

PRESIDENT ORTON: We have listened to an interesting paper from Mr. Hughes, which I think should elicit the fullest discussion. Remarks along this line are in order.

MR. KANE: I am sorry I have to leave in a few minutes, for I should like to have heard this paper fully discussed; but before I go there are one or two questions I would like to ask Mr. Hughes. He has made a comparison between the electric haulage and the tailrope haulage, and the comparison favors the tailrope haulage. Now, that being the case, if there isn't any drawback to the tailrope system, it is certainly preferable as compared with the electric system. I have had a good deal of experience with the tailrope system, in the repairing of shafts, wheels, pulleys and things of that kind. Here is the point: you are liable to very frequent breaks by the tailrope system, because of the fact that the cars are connected by chains, and in your set of cars you have a factor you can hardly govern. I do not know anything about the electric system, but I imagine they are hauled by electric locomotives. Is that correct?

MR. HUGHES: Yes, sir.

MR. KANE: My own judgment is that there is less liability of stoppages and breaks and wrecks with a locomotive drawing the cars, and that they can be regulated a good deal better by locomotive than by the tailrope system. Is it not a fact that the freedom from wrecks and breaks in use of the electric system will counterbalance the twenty-five per cent. in favor of the tailrope system, taking into consideration, too, the other advantages of having an electric plant in operation at the mine? If you have an electric plant there it can be used for lighting and a good many other purposes. If you have the tailrope system, you have nothing but the tailrope and a good deal of bother with breakages and expense of repairs. I do not know that these things are as I depict them, but I ask if this is not the case, Mr. Hughes?

MR. HUGHES: This is just what I want: I want to learn a good deal and tell a little bit. The wear and tear on the electric system is more than with the tailrope system. There is not an electric system in operation to-day that I have been able to find, where in the first twelve months they have run thirty consecutive days. Now, then, let a man install the tailrope system and make that statement and the man would have to go out of the business. The electric system costs all the way from twenty-five per cent. to sixty-five per cent. per annum for wear and tear. I have a plant in my mind's eye, which cost ninety thousand dollars to install. The comparison between the tailrope system and this one would be about as between the tailrope and the time when our wives carried the coal out in buckets on their heads. This plant, I am pretty straightly informed has not equalled the output of the mules; and though they put ninety thousand dollars into the plant, they are ready to put it into the scrap pile. I would be willing to put in the tailrope system and enter into a ten year contract to do the hauling if they would give me pro rata what it cost the past year for repairs. The past year's repairs would pay me for putting it in and would pay for hauling.

MR. LOVE: I am not very well versed in the different systems of haulage in question, but I know of some two or three electric plants for haulage and I must say it is a very slow way of getting out coal, compared with the tailrope. However, electric haulage may be much improved in the future, but it has not amounted to anything so far. As to the cost of insulation, it must be immense compared to the tailrope. The tailrope is a success on grades where electric haulage could not be used at all.

MR. BEATTIE: I differ with Mr. Love in regard to electric power being slower than rope haulage; but it has disadvantages. It is more susceptible to wrecks and breakdowns than rope haulage, because the power is more positive and not so easily controlled. We have both systems in the district I represent, and wrecks are less with rope haulage than with electric. And when the motor breaks it is harder to repair, takes more expert men to repair it. I know one instance where the electric motor broke down and it took ten days to repair it, the men being idle all that time. In case of a wreck on the rope haulage system, perhaps an hour or two will mend it and the men can get to work again. So I believe that rope haulage is more practical in mines than electric haulage.

MR. MILLER: My favorite is electric haulage. It is true that electric haulage is something like rope haulage, if the plant is not put in right. We have electric haulages in this State which are successes and others which are not. I visited a friend of mine last winter in Indiana. His plant is equipped with electric system. He uses Jeffrey machines for mining the coal and motors for hauling it. I must say it was the finest haulage system I ever saw. He explained to me the expense of the plant, and in looking over his books he showed me that for nine months in succession the plant did not cost a cent for repairs for mining machines or haulage. I don't think you could say that much for rope haulage. The tailrope system takes so many mine cars and they are expensive. You cannot get a good mine car for less than twenty-six or twenty-seven dollars. With the electric system, you can take a dozen, or as many cars as you have. You cannot do it with the rope system very well. Of course it can be done, but your run is too great. The wear and tear is too great on that rope to run four or six thousand feet with half a dozen or so cars. It would not be on the motor. You would have wear and tear there, but not so extensive as it would be on the rope. I am in favor of electricity.

MR. HUGHES: The question is whether in this Indiana plant, where they ran nine months without repairs, whether the man is earning six per cent. on his electric investment over the output of the same amount of coal with rope haulage, either tailrope or endless. In other words, electricity to-day, while in one sense a mechanical success, we cannot all afford to apply to haulage, because we are all after cold-blooded dollars, and to be a success you must know that you are going to get six per cent. on your investment in the electric haulage plant over and above the output of coal if you did not put that investment in it. That plant which cost ninety thousand dollars would have to earn six per cent. on the difference between that and the cost of rope haulage to make it a success. Can you increase the output of coal now to make it a financial success?

MR. MILLER: You can only run so many miles an hour. Should you increase the speed beyond that and meet with a wreck, the whole train is wrecked.

MR. HUGHES: The limit of the output is controlled by the weight of the electric motor, or the amount of money you put into it.

PROFESSOR RAY: In regard to the comparative cost of the two systems, I had a good experience which gives me an opportunity to have them tested by comparative bids on a system in which the requirements were definitely stated in every detail. We received bids from a responsible manufacturer of electric supplies and also from a responsible maker and builder of tailrope haulages; and it is a mistaken idea for the members of this Institute to get into their heads that you must spend this vast amount of money for practical electric haulage. The result of these bids was in favor of electric haulage. The firm guaranteed to put in the plant complete for a little less than twelve thousand dollars, by using electric haulage, including engine, dynamo, two motors, etc. The tailrope man was very close to that figure, something like a hundred or two hundred dollars higher; so there is practically little difference in the first cost. The question of selecting haulage comes right back to a question of judgment again. If you have steep inclines, say greater than three or five per cent. on the outside, then it is useless, in my judgment (and that is based on experience) to try to pull coal up that incline successfully by means of a locomotive or electric motor,—in other words, by traction. In such case tailrope, or some system of rope haulage or positive pull should be adopted. But in any place where you have less than that per cent. of incline, between a level track and that per cent., then you can select either tailrope or electric haulage. The tailrope has been so successful that I am a little in favor of tailrope, providing that the distance is not greater than one mile. Even at one mile distance the friction is so great that it reduces the power of your engine to handle the loads. It is possible to imagine that distance so great that the power of your engine will be consumed in pulling the rope alone. That has been practically demonstrated in one of our largest mines, at Jobs, one of the places we expect to visit on our excursion. It is a very large mine and they have a very good tailrope system there, and they haul something like forty-five cars. The distance increased to something exceeding a mile and it became a serious problem, as the mine advanced. At the last time I had a talk with the superintendent, he was seriously considering putting in electric haulage at the end of the rope and use the motors to bring the coal to the ropes and then pulling it out on the tipple. It would be impracticable in that case to use a motor on the tipple, as the incline is steep. I think nearly five per cent. on one side and a little less on the other. Electric power is recognized as the most economical means of transmitting, and for that reason is well adapted for the use of electric haulage at long distance. The mine can also be so wired that the same current can be used in the running of mining machines. In cases where mines are equipped with electricity for cutting coal, I think it advisable to use electric haulage, because you simplify and lessen the number of machines you have to look after. In places where compressed air is used, then I think that a man's preference could be taken,—he could use either electric or tailrope.

MR. CARDING: I think the last remarks were to the point. When you have electric plant for cutting coal, the best method is to put in electric haulage, thereby concentrating the work in one machine. But if you have not an electric plant in, I think the tailrope is preferable to electric haulage, because it is considerable expense to keep up an electric plant. You must have a first-class electrician to be successful. I had a little experience in that regard. The company thought they could get along without a practical electrician and lost money every day. They finally secured a practical electrician and the plant became a success. Where you are digging coal with picks and not contemplating putting in machines, the tailrope system is the best. Any man of ordinary skill can attend to it.

SECRETARY HASELTINE: Professor Ray's statement of the position of the bids on the two systems of haulage is a little misleading, if I understand correctly, in this respect. The bid for twelve thousand dollars for rope haulage included the entire equipment ready for business; while the twelve thousand dollar bid for electric haulage fell short to the extent of the necessary track on which to make electric haulage successful. With rope haulage of any kind, any business done in Ohio can be done on an eighteen or twenty pound steel rail. To haul coal economically, where an electric haulage plant is put in, it will require rail in the neighborhood of forty pounds, with an increase in the number of ties and a road bed of superior quality in every respect. In figuring upon that proposition, it has been clear to me always that a tailrope system on ordinary rails, was a much cheaper plant than the electric motor upon a rail heavy enough and upon sleepers thick enough to make it economical. The use, as Mr. Carding suggests, of electric haulage where you have an electric plant as against rope haulage, presents to me this feature: that where you have electricity, it is worth more to an operator as a power to cut coal than to haul it. That is, you can haul coal with the tailrope system for less money than you can supply the electricity. You can haul the coal for less money than it would cost to cut the amount of coal by pick mining. And it is a very rare occurrence to find a plant equipped with an excessive amount of electricity. They are always equipped to the very limit of the amount they want and none to spare.

PROFESSOR RAY: Mr. President, just one point. I want to say that the bid for electric haulage, of which I spoke, included the track as specified, a forty pound rail, complete. I will say further that a good track is a good thing to have in any kind of haulage. You can have a tailrope system work on a sixteen pound rail fairly well, but your repairs on a sixteen pound track will be greater than if you would put in a forty pound rail. You can get a great many points along this line from experts on steam railways. The same laws control the question of railways underground as above.

(Upon motion adjournment taken until evening session, at which time discussion of Mr. Hughes' paper will be resumed.)

EVENING SESSION.

January 22, 1896.

President Orton called the meeting to order and announced that, if it was so desired, the discussion of Mr. Hughe's paper, which was in progress at the time of the adjournment of the afternoon session, would be resumed.

PROFESSOR LORD: I want to ask a question about the occasional crystalization of the metal in wire ropes.

MR. HUGHES: In reply I will say that there is a mistaken idea as to what extent crystalization occurs in the use of wire rope. The general impression seems to be that it is quite common. Such is not the case. It can only occur from two conditions, in fact I might say from one. One, which would be running at such a high rate of speed that it would be unsafe to run it, I will ignore. The other condition is caused by a mechanical defect in construction. If you will notice, the wire rope for mining is always made with a hemp or manilla center. Crystalization can be caused by that manilla center being too small for a given diameter of rope. In other words, for a rope seven wires to the strand, the center should be one third of the diameter of the rope in its finished or work condition, after it has been strained out. If it is not large enough, when it is strained to a working capacity, it will squeeze the outside down onto the center to a point where internal friction occurs. Then the outside six strands vibrate against each other, they crystalize and crack internally. This is not visible in the operation of the rope. When this occurs, it is the fault of the rope-maker. If the center is too small to act as a cushion for the outside strands, then it is the same as a hollow center, causing friction and crystalization and cracking of the inside wire, while the outside looks unworn and safe. When it breaks, when the outside is only apparently a little worn, it is safe to come back on the rope-maker. Again, if you find one wire taking all the abrasion and worn more than the other six, that is the fault in manufacturing. Perhaps you are wondering why I am discussing all the faults of rope-making—I expect the rest to respond to the virtues. In twisting the strands into a rope, six of them are revolved around a central shaft and there twisted into a rope. Now, then, to have each one take its proportional strain, each wire in a strand and each strand in the rope is put under a proportional strain. There is an indicator on the machine to show just what strain they are under; and each wire in each strand is strained up to take is proportion of the load. So if the rope is perfectly made, each of the forty-nine wires will wear down and take its own proportion of abrasion. Then if one wire shows wear when its neighbors are untouched, it is produced by that one wire having slipped the tension; the man who watches the machine has not attended to his business, and it has gone through with this tension off instead of on.

Secretary Haseltine: In testing the ropes in the State, we find here and there a rope with an end of wire projecting a portion of an inch, apparently without any other end. The rope does not appear to be worn, but this wire simply projects. I would like to know whether that is a broken wire, or is it the end of a coil as it has been started in in weaving the rope? Another question I would like to ask Mr. Hughes, is as to the best method to be employed by us as mine inspectors in testing the safety of a rope.

Mr. Hughes: A rope made for a coal shaft is made with nineteen wires in a strand instead of seven for an incline. That will make one hundred and forty-four wires over which to distribute the strain. Suppose one wire snaps,—that does not make any difference; but if it is cracked all the way along, then it is a bad wire, too highly carbonized to take the twist. Even in that case you have but lost one hundred and forty-fourth part of the rope's strength. But if one strand shows wear all along the rope, then you have lost one hundred and forty-fourth. It is a defect in manufacture which rarely occurs.

As to the question as to a mode of testing ropes, that is something I can answer by saying it cannot be answered. The general rule is, if all the outside wires are wearing uniformly, and are worn pretty near half way before cracking, take the rope out soon after the cracking begins, because it will begin cracking generally after it is half worn. But if it begins cracking generally and is not worn down, then it has been made of too highly carbonized steel, and it is safe to abandon it as soon as you can. Generally speaking, I do not think any division of the mechanical arts has had closer study and attention than the manufacture of wire rope. It is to-day fifty years ahead of what it was ten years ago. In all rope factories the system of testing and inspection is more thorough than perhaps in any other of the mechanical arts. It has now reached a point where a manufacturer of wire rope would be almost ashamed to own that a product was his that had all the defects which have been discussed to-night.

SECRETARY HASELTINE: I would like to ask Mr. Hughes to explain to us the mode of making eliptic and different shaped ropes which we see, and as to their comparative safety and working abilities with round ropes.

MR. HUGHES: That is rather a delicate subject to go into, and I would like it clearly understood by all the members that in discussing it I am now expressing a personal opinion and not a manufacturer's opinion. On that basis I will take first the interlocking rope, a rope manufactured in England since eight or ten years, ago, and for the past six years in this country. The wire is made Z shape, and at the bottom is a round wire that acts as a lock in holding the outside wires in their true position,—hence the phrase, interlocking. It is the most beautiful rope ever made, has an entirely spherical surface and is as smooth as polished brass.

It is an ideal rope where you want to use it for a carrier rope for ferry or tramway railroad, where the wear is only from a pulley running over it. Theoretically there is this objection—I would rather the other gentlemen would decide whether it is practical or not. When the rope runs over a shaft in a mine, it forms to some degree an elipse, or becomes egg-shaped. The strain, of course, is at the point of contact with the shaft and opens up the wires at the top like that (indicating). There is no coal shaft where there is not grit and dust at the head. This drops in between the wires and as it comes over the shaft it closes over it again. The question is, does it lock up the grit inside and then sqeeze it into the internal portion of the cable. If it does, that grit is bound to act on the pocket of round wires and force these wires out of position. The moment that condition arises, the rope collapses. You never know with an interlocking rope where you are. It is as good a rope after a year's service as after an hour's service; but a great many cases have arisen where the rope has collopsed.

There is another rope with a flat center,—with seven, nine and fifteen wires around a flat wire. It is a compromise between the other two. But the difficulty with this is, when it takes an abrasion, it is bound to prodce a spreading of the top wires on the flat ribbon. The minute it does that, it causes the flat ribbon to bulge up, so you cannot equally distribute the strain on the six strands; but the one protruding takes the abrasion and its neighbor squeezed down takes the tensile strength.

PRESIDENT ORTON: We have with us a man possessed of technical information of a high order who is generous enough to give the members of the Institute information from the inside. I think Mr. Hughes deserves great credit and our most hearty thanks for what he has given us this evening.

SECRETARY HASELTINE: I wish to ask Mr. Hughes one more question. We have adopted a mode of examining the ropes at the shafts, as follows: We select a piece of loosely-woven rope, take one turn around the rope, which (generally is very heavily coated with coal tar) have one person at each end, and if there are any wires projecting in any way, they catch in this rope.

I would like to ask if in your opinion this is a suitable way and the best way of detecting broken wires in rope, and whether the wires that catch in the hemp are really broken wires?

MR. HUGHES: I would say yes, that you have found broken wires. It is only about a ten minute operation, or less, for your tipple man every morning to start the engine slow, so he can see the wires as they pass over the head shaft. This daily inspection would give absolute confidence in the rope. The rope cannot deteriorate in twenty-four hours from a point of safety to risk. In fact, if the wires are half worn through and twenty-five per cent. cracked, you still have a safety factor of three over and above the strain put on it under proper conditions. So if you go over the rope every day, you are bound to know three months ahead of danger. It may have occurred to you that I have pretty freely discussed the defects which may develop in wire ropes; but let me tell you that every rope-maker is protected from anyone jumping on him for killing John Smith. Every wire made in the wire-room is put to a test as to tensile strength. The man who tests this has no idea that the rope is going into your shaft. He gives a certificate of this test and the man in the rope room certifies that he has taken the wire handed to him on such a day by such a man, and so on. If your rope breaks under a twenty-ton strain, under a guarantee of a twenty-five ton strain, he will come back at you with a very close scrutiny as to what produced the breakage. It will develop that there was a screw loose at your end; and he can prove that it was actually impossible for that rope to break under twenty-five tons, for an allowance had been made exceeding every table published. The manufacturer takes no risk of getting down to the margin, but exceeds the tabulated figures by at least five per cent. If there is an excess of five per cent. on one wire, you can readily figure that he has a very large margin of safety to protect him in any suit for damages.

SECRETARY HASELTINE: I move we extend a vote of thanks to Mr. Hughes for presenting this very able paper and favoring us with the valuable discussion of the subject.

(Seconded and carried unanimously.)